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Scleroderma stellatum versus *Scleroderma bermudense:* the status of *Scleroderma echinatum* and the first record of *Veligaster nitidum* from the Virgin Islands

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Abstract: The type of *Scleroderma stellatum* from Brazil exhibits a sharp echinulate, dark brown peridium, and the type of *S. bermudense* from Bermuda has a peridium that is loosely woven and fibrillose, whitish to pale brownish. These characters indicate two independent species. This information is contrary to that of Guzmán in 1970, who interpreted *S. bermudense* to be a synonym of *S. stellatum* based on the similar spores. *Scleroderma echinatum* from Borneo and Panama, as recently discussed by Guzmán and Ovrebo, also has an echinulate, dark brown peridium and is a synonym of *S. stellatum.* All these fungi have a stellate dehiscence. New records of *S. bermudense* from the Greater Antilles and Mexico's Pacific Coast, and *Veligaster nitidum* from Virgin Islands also are discussed.

Key words: Gasteromycetes, new records, *Scleroderma,* Sclerodermataceae, tropical fungi, *Veligaster*

INTRODUCTION

Recent information and new material on *Scleroderma* species with stellate dehiscence gathered by Reid (1977) in Trinidad, new collections by the senior author from the Pacific Coast of Mexico, new collections by Miller and Lodge in the Greater Antilles including Puerto Rico, the Dominican Republic and Virgin Islands, and additional collections by Ovrebo from Panama moved the authors to re-examine and revise the status of *S. bermudense* Coker and *S. stellatum* Berk. The senior author first considered *S. bermudense* to be a synonym of *S. stellatum* based on the stellate dehiscence and similar structure of the spores in both fungi (Guzmán 1970). However, a restudy of the poorly preserved holotype of *S. stellatum* showed it possessed an echinulate, chocolate-brown peridium, unlike *S. bermudense,* which has a loosely woven and pale peridium. In addition, *S. echinatum* (Petri) Guzmán, recently studied by Guzmán and Ovrebo (2000) from Panama, has the same peridium characters as those observed in *S. stellatum.*

This paper presents a revised concept for *S. stellatum* and its synonymy with *S. echinatum,* while removing it from synonymy with *S. bermudense,* which we now consider to be an independent species. The distribution of *S. bermudense* is expanded, and its close association with *Coccoloba uvifera* (L.) Jacqu., a putative ectomycorrhizal associate, also is reported. Last, *Veligaster nitidum* (Berk.) Guzmán & Tapia is reported for the first time from the Virgin Islands in the Greater Antilles.

MATERIALS AND METHODS

Macro- and microscopic studies of the types of *Scleroderma stellatum* and *S. bermudense,* as well as recent collections from Bermuda, Panama, Puerto Rico, the Dominican Republic, Virgin Islands and Mexico, are the basis of this work. Microscopic observations were made from rehydrated sections of basidiomata mounted in 5% KOH, in lactophenol, or in 1% Congo Red mixed on the slide with a drop of 5% KOH. Color comparisons were made using the plates of Kornerup and Wanscher (1967) (e.g., 12F2-3).

RESULTS

Scleroderma stellatum Berk. in Hooker's J & Kew Gard Misc 8:278, 1856. FIGS. 1–10 and 24

= *Caloderma echinatum* Petri, Malpighia 14:132, 1900 (!).
= *Caloderma petrianum* E. Fischer, in Engler & Prantl, Natürl Pflanzenfam 7a, 2, p. 38, 1933 (!).
= *Scleroderma echinatum* (Petri) Guzmán, Ciencia 25: 200, 1967 (!).
= ? *S. violaceum* Lloyd, Myc Writ 7:1306, 1924.
= ? *Sclerangium brasiliense* P. Henn., Hedwigia 43:154: 1904.

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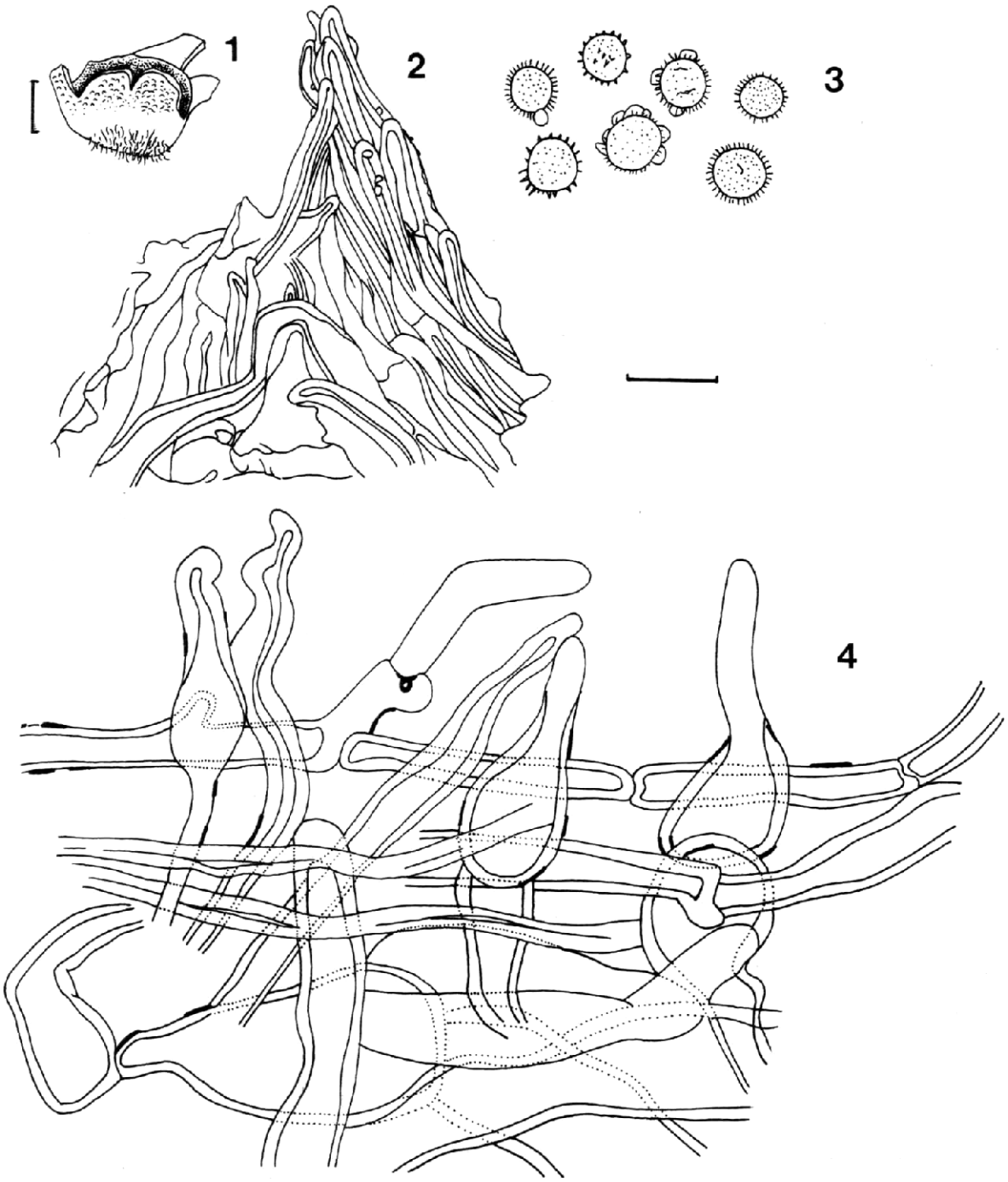


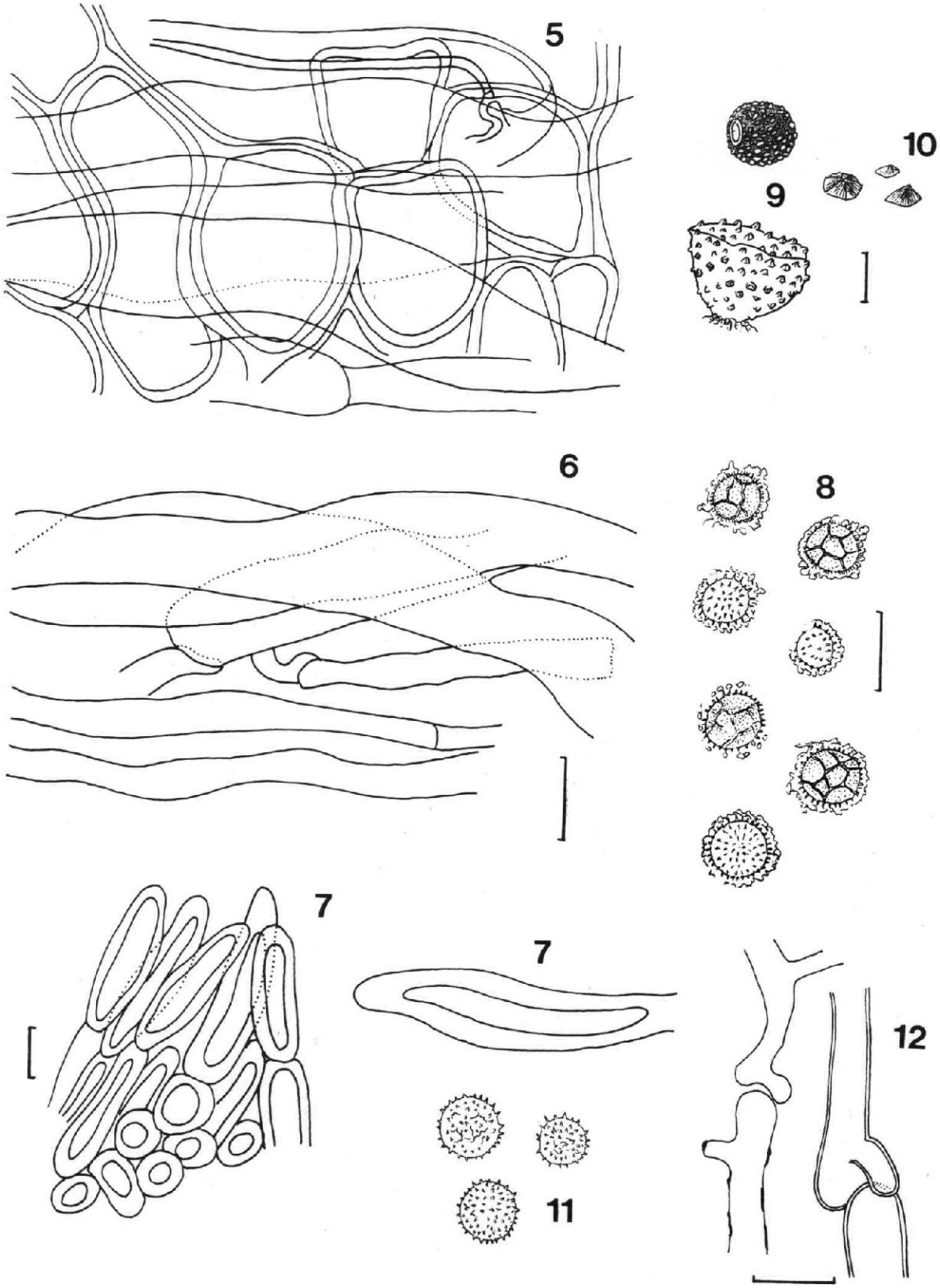
FIGS. 1–4. *Scleroderma stellatum*. 1. Basidiome (reconstructed). 2. Scale of the exoperidium. 3. Spores. 4. Hyphae and cells of the exoperidium base (all from the holotype). Scale bar: FIG. 1 = 10 mm, FIGS. 2–4 = 10 μm.

non S. stellatum Berk. sensu Guzmán, Darwiniana 16:310, 1970.

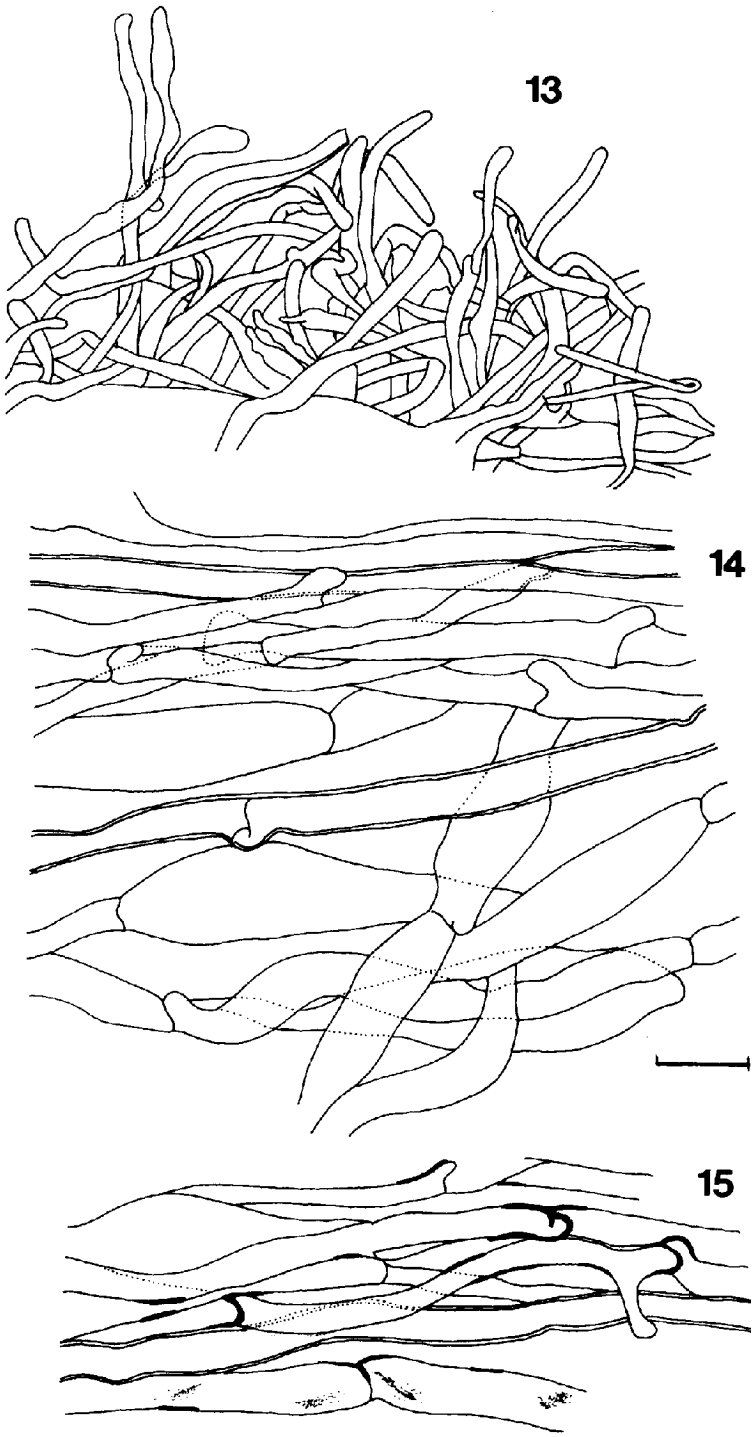
non S. bermudense Coker, Mycologia 31:624, 1939 (see below).

non Caloderma echinatum (Sacc. & Paoletti) E. Fischer, in Engler & Prantl, Natürl Pflanzenfam 7a, 2, p. 38, 1933 (*Tuber echinatum* Sacc. & Paoletti, Atti R Inst Veneto Sc Lett Art 6, ser 6:27, 1888; *Neo-saccardia echinata* [Sacc. & Paoletti] Mattirolo, Atti R Acc Sc Torino 56:27, 1921).

Basidiomata (FIGS. 1 and 9) globose or subglobose, sessile or very shortly stipitate, up to 45 mm diam, with a thin peridium up to 0.5 mm thick, elastic and brittle in dried specimens, reddish brown to very dark brown, hardly echinulate, with thick, pyramidal scales or spines, up to 1.5 mm high above and shorter near the base (FIGS. 9–10), and which are acute or stellate when mature, base of the peridium pale,

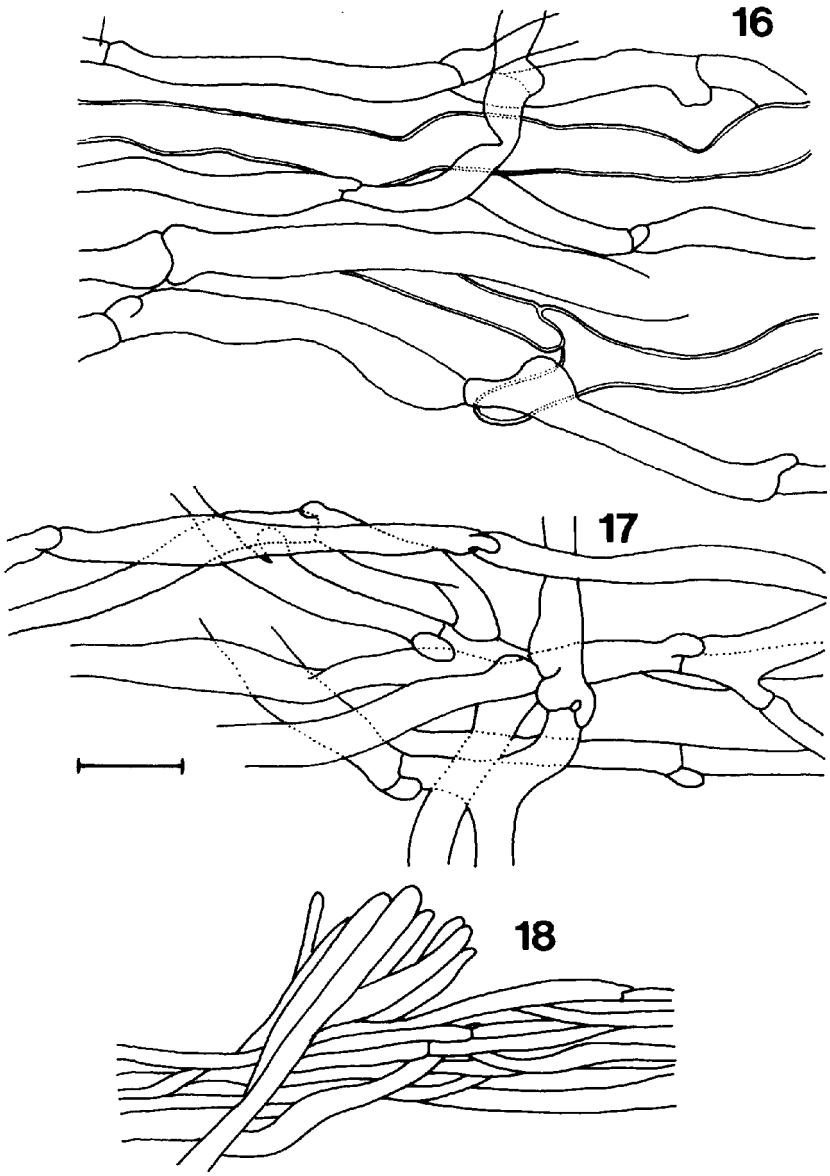


FIGS. 5–12. *Scleroderma stellatum* and *S. bermudense.* 5–10. *S. stellatum,* 5. Mesoperidium. 6. Endoperidium. 7. Scale of the exoperidium. 8. Spores. 9. Basidiomata (young and mature). 10. Scales of the peridium (FIGS. 5–6 from the type; FIGS. 7–10 from Vitter 5717 first considered *S. echinatum*). 11–12, *S. bermudense,* 11. Spores. 12. Tramal hyphae in the gleba (Guzmán 32973). Scale bar FIGS. 5–8 and 11–12 = 10 μm; FIG. 9 = 10 mm; FIG. 10 = 3 mm.



FIGS. 13–15. *Scleroderma bermudense*. 13. Exoperidium. 14. Mesoperidium. 15. Endoperidium (Miller 27245). Scale bar = 10 μm.

smooth or covered by short, mustard-yellow filaments (FIG. 1). Dehiscence by irregular or torn tear, open stellately in holotype and Ovrebo 4049, or sometimes by an apical irregular pore (*Vitter 5117*). Gleba fleshy when young (in material from Panama), subareolate in holotype and other collections, dark purple to brownish violet, with white, thin, irregular filaments, powdery with age, dark brownish violet, with a few irregular white filaments, which eventually disappear. Spores (5–)6–7(–9) μm diam (FIGS. 3, 8 and 24), including the spines, which are up to 1.5 μm long, forming a subreticulum, although the young spores



FIGS. 16–18. *Scleroderma bermudense*. 16. Mesoperidium. 17. Endoperidium. 18. Exoperidium (FIGS. 16–17 from Miller 27245, FIG. 18 from Guzmán 21087). Scale bar = 10 μm.

are without a reticulum. Exoperidium formed by fascicles of erect hyphae (FIGS. 2, 4 and 7), thick-walled (up to 6 μm thick), yellowish brown or reddish brown, 38–130 × 7–35 μm, smooth or encrusted, apex obtuse or acute, sometimes capitate. Mesoperidium (FIG. 5) subcellular, with globose elements, up to 35 μm diam, thick-walled, walls up to 3 μm thick, hyaline (yellowish in mass), mixed with long, hyaline hyphae, 4–20 μm wide. Endoperidium (FIG. 6) thin and formed by hyaline, thin-walled hyphae, 4–20 μm wide, surrounding the gleba. The filaments at the base of the exoperidium (FIG. 4) are formed by thick-walled, cylindric or sublageniform elements, 5–10(–20) μm wide, with brownish yellow walls, up to 2 μm diam arising from prostrate, branched, hyaline hyphae, 2.5–18 μm wide, thin to thick-walled, smooth, with brown encrustations.

Habitat and distribution. Solitary or gregarious on soil, in tropical rain forests. Patouillard and Gaillard (1888) reported it on an ant nest. It is known from Brazil (Berkeley 1856, Berkeley and Cooke 1877), Venezuela (Dennis 1970, Patouillard and Gaillard 1888), Panama (Garner 1956, Guzmán and Ovrebo 2000), Borneo (Petri 1900).

Specimens examined. VENEZUELA, Amazonia, Panuré, 1884, *Spruce?* (holotype K[M] *105766*). PANAMA, San Blas, Port Obaldia, Sep 1911, *Vitter 5717* (BPI); Panama Canal Zone, Barro Colorado Island, 12 Jul 1925, *Dodge* (BPI); Mill-

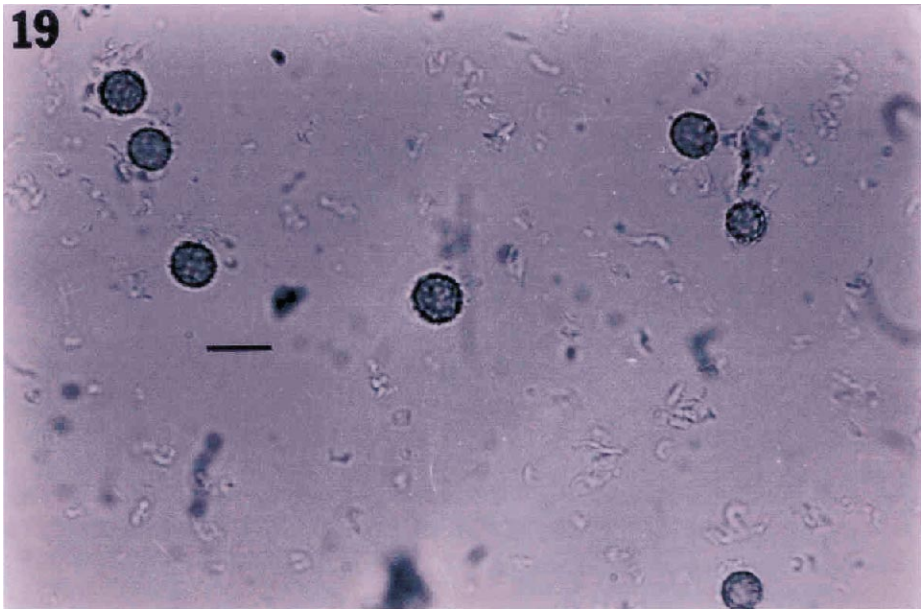


FIG. 19. *Scleroderma bermudense,* basidiospores (note the collapsed hyphae of the trama and the ''nurse cells'') (Guzmán 32937). Scale bar = 10 μm.

er Trail, 11 Aug 1997, *Ovrebo 3603*; 14 Aug 1997, *Ovrebo 3638*; Latham Trail, 7 Aug, 2001, *Ovrebo 4049* (all of them in SCZ and XAL, except the last, which is in SCZ).

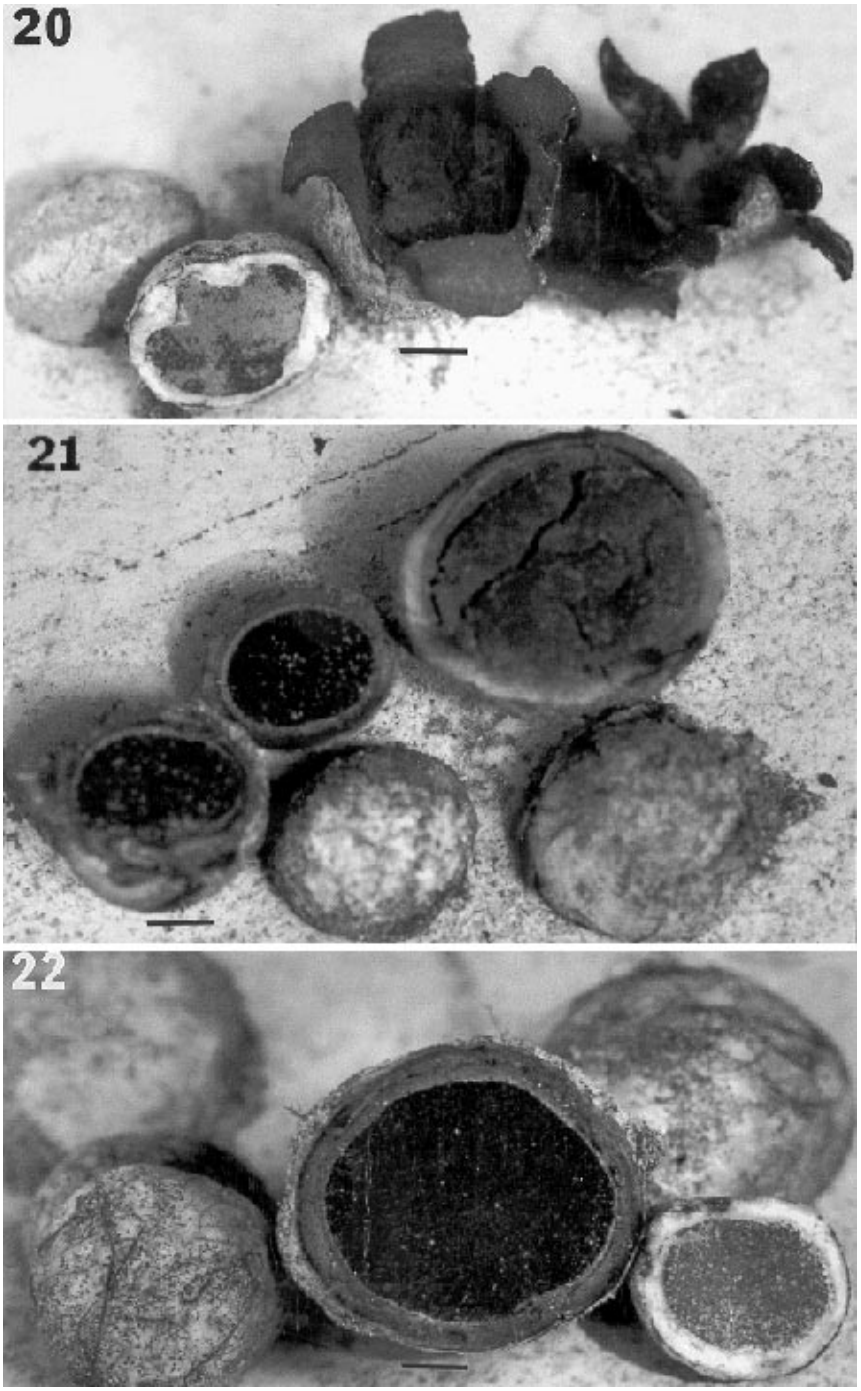
Comments. *Scleroderma stellatum,* described by Berkeley (1856) from Panuré, Venezuela, was considered by Guzmán (1970) to possess an off-whitish to straw-colored, smooth or somewhat scaly peridium. With this concept, Guzmán (1970) considered *S. bermudense* to be a synonym of *S. stellatum,* which has the same type of spores and stelliform dehiscence. However, a recent restudy of the type by Guzmán and Ramírez-Guillén, confirmed by Lodge, revealed that the peridium has acute brown scales, formed by thick-walled, dark brown, raised hyphae, resembling those observed by Guzmán (1970) and Guzmán and Ovrebo (2000) in collections of *S. echinatum* from Panama. Berkeley's (1856) original description of the peridium was: ''rough with minute, stellate warts.'' The description of *Caloderma echinatum* by Petri (1900) and *C. petrianum* by Fischer (1933) agrees with the type of *Scleroderma stellatum*. The fungus described by Saccardo and Paoletti as *Tuber echinatum* from Malaysia in 1888, and considered by Mattirolo (1921) as *Neo-saccardia echinata,* and by Fischer (1933) as *Caloderma echinata,* appears to be another species of *Scleroderma,* close to *S. echinatum*. The type of *Caloderma echinata* unfortunately appears to be lost (Guzmán 1970). *Neo-saccardia echinata* has large spores, 10–12 μm diam not including the spines (Mattirolo 1921). The synonymy of *Caloderma* Petri (1900) with *Scleroderma* follows the concept of Guzmán (1970), based on the absence of a true capillitium and the development of the spores after they are expelled from the basidia and surrounding by cells (known as ''nurse cells'') of the collapsed trama. This concept first was presented by Clements and Shear (1957). *Scleroderma stellatum* s. Patouillard & Gaill. reported from Venezuela by Dennis (1970) seems to belongs to *S. stellatum* s.s.

Guzmán and Ovrebo (2000) classified *S. echinatum* in the new section *Caloderma* Guzmán & Ovrebo of the genus *Scleroderma*. This was based on the structure of the echinulated peridium, formed by thick-walled, brown hyphae, not seen in other species of *Scleroderma*.

The probable synonymy of *S. violaceum* Lloyd and *S. stellatum,* described by Lloyd in 1924 (Lloyd 1898–1926) from the Congo and considered doubtful by Guzmán (1970), is based on the study of the poorly preserved type: Lloyd 24888 at BPI. The material has a thick, dark-brown peridium and seems to have minute warts. The spores are similar to those found in *S. stellatum*. Another probable synonym of *S. stellatum* is *Sclerangium brasiliense* P. Henn., described from Amazonia in Brazil (Hennings 1904). The type appears to be lost (Guzmán 1970), but the description of the fungus indicates the peridium was ''rufobrunneo squamoso'' and thick with a stellate dehiscence.

Scleroderma bermudense Coker. Mycologia 31:624, 1939. FIGS. 11–22 and 25

= *Sclerangium bermudense* (Coker) Reid, Kew Bull 31: 681, 1977.



FIGS. 20–22. Basidiomata of *Scleroderma bermudense* (FIG. 20 from Miller 27349. FIG. 21 from Miller 27237. FIG. 22 from Miller 27245). Scale bar = 5 mm.

= *Sclerangium bermudense* var. *trinitensis* Reid, Kew Bull 31:681, 1977.

Basidiomata globose to subglobose, 18–34 mm wide, smooth or with shallow depressions over the surface, dingy white or tinted gray, with gray to brown rhizomorphs and loose arachnoid hyphae and clinging sand over the surface (FIGS. 20–22). Dehiscent at maturity, splitting to form a roughly stellate pattern (FIG. 20) of 4–6 rays. Gleba firm, subareolate, with white filaments, deep purple (12F2-3 to 14F4-5), light purple (12B3-4) to dull grayish purple (10E2-3) with age. Peridium 2.5–3 mm thick, 1–1.5 mm when dry, surface whitish to pale brown, or pale gray, formed by loosely woven fibrils. Context yellowish brown or with a light pink tint. Peridium is formed by three layers: exoperidium, mesoperidium and endoperi-

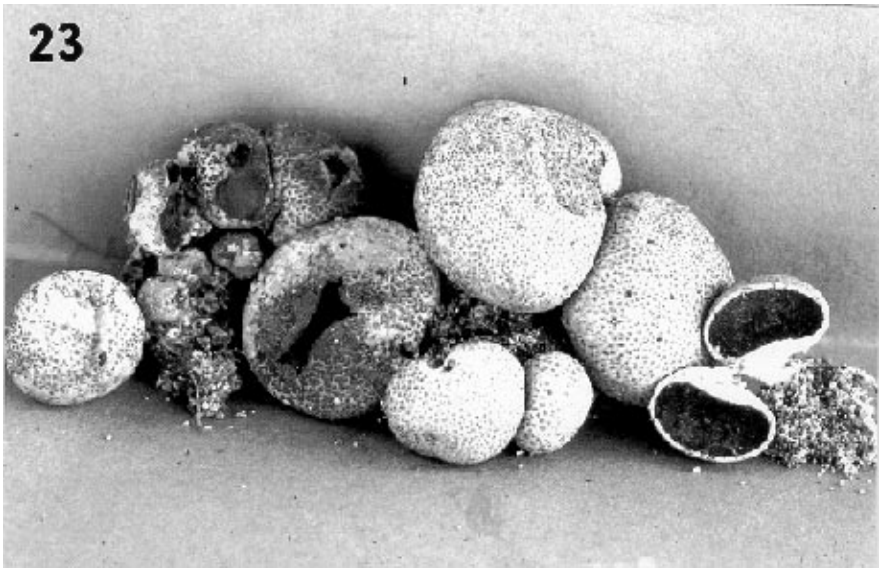


FIG. 23. *Veligaster nitidum* (Lodge G-167). Natural size.

dium. The first (FIGS. 13 and 18) is formed by hyaline, prostrate to suberect or mixed hyphae, 2–6 μm wide, sometimes with 10 or more hyphae in fascicles, up to 70 μm high, thin- to thick-walled, walls up to 1.5 μm thick; hyphae smooth or lightly encrusted, with the apex obtuse or rostrate. The mesoperidium (FIGS. 14 and 16) is formed by hyaline, thin- or thick-walled hyphae, sometimes inflated, 3.5–20(–26) μm wide. The endoperidium (FIGS. 15 and 17) is formed by thin- to thick-walled hyphae, 3–7 μm wide, that forms a thin cottony membrane surrounding the gleba. This is not a true endoperidial layer, as observed in other gasteromycetes (e.g., *Geastrum*), because it is a thin (<0.1 mm thick), ephemeral layer, that disappears when the basidiome opens by the dehiscence. Spores globose, 5–7(–10) μm diam, including the spines, which are 0.4–1 μm long, forming a partial reticulum at maturity (FIGS. 11 and 19); surrounding by hyaline, thin- or thick-walled tramal hyphae, with clamp connections and "nurse cells" (FIGS. 12, 19 and 25).

Habitat and distribution. Gregarious on sand, epigaeous or subhypogaeous, in coastal marine sand dunes, in tropical or subtropical regions, usually under *Coccoloba uvifera* and probably other species of *Coccoloba* (see below). It is a putative-ectomycorrhizal associate with *Coccoloba* and appears to follow the distribution of *Coccoloba* throughout the tropics. *Scleroderma bermudense* was described from Bermuda by Coker (1939) and recorded later by Waterston (1947). It also is found in the Bahamas, Barbados, Florida, Puerto Rico and Malaysia (Guzmán 1970), Cuba (Kreisel 1971), Trinidad (Reid 1977) and Mexico (Guzmán 1983, 1986). It is interesting to observe that the type locality of *S. bermudense* is known as Grape Bay and that the common name of *Coccoloba uvifera* is "sea grape". All specimens found by Guzmán in Mexico and Miller and Lodge in Puerto Rico and the Virgin Islands were under or close to *C. uvifera*. According to Standley (1920–1926), *C. uvifera* grows on all Gulf of Mexico coasts, as well as the Pacific Coast of Mexico, as well as other species including *C. goldmanii* Stand., *C. lapathifolia* Stand. and *C. schiedeana* Lindau, in the West Indies, Central America and northern South America. However, in Mexico, *Scleroderma bermudense* is known only along the Caribbean Coast (Guzmán 1983, 1986). Guzmán carried out field work several times along the Mexican Gulf of Mexico coast without finding *S. bermudense*. The Malaysian record cited by Guzmán (1970) is based on a specimen gathered by Weir in 1926. These collections at Beltsville (BPI) need to be restudied, due to the previous confusion with *S. echinatum*. However, a new record of *S. bermudense* has been found at Ixtapa-Zihuatanejo, Guerrero, Mexico, at sea level in sand with *Coccoloba uvifera* by the senior author (*Guzmán 32973,* XAL). This new record of *S. bermudense* on the Mexican Pacific Coast agrees well with the type and with all studied materials.

Specimens examined. BERMUDA ISLANDS, Grape Bay, 29 Nov 1938, *Seaver & Waterston 15A* (holotype, NY); 27 Nov 1940, *Seaver & Waterston 336* (NY); Elbow Beach, 4 Dec 1938, *Seaver & Waterston 119* (NY); 11 Dec 1938, *Seaver & Waterston 183* (MICH; NY); *Whetzel* (NY). BAHAMAS, Long Cay, *Brace 4226* (NY); *Britton* (NY). PUERTO RICO, Jan 1923, *Seaver & Chardon 128* (NY); *Seaver & Chardon 503* (NY); Guanica, 1915, *Britton 4922* (NY); near Loiza, Piñones Beach, 19 Nov 1996, *Baroni 8350* (CORT); 27 Feb.

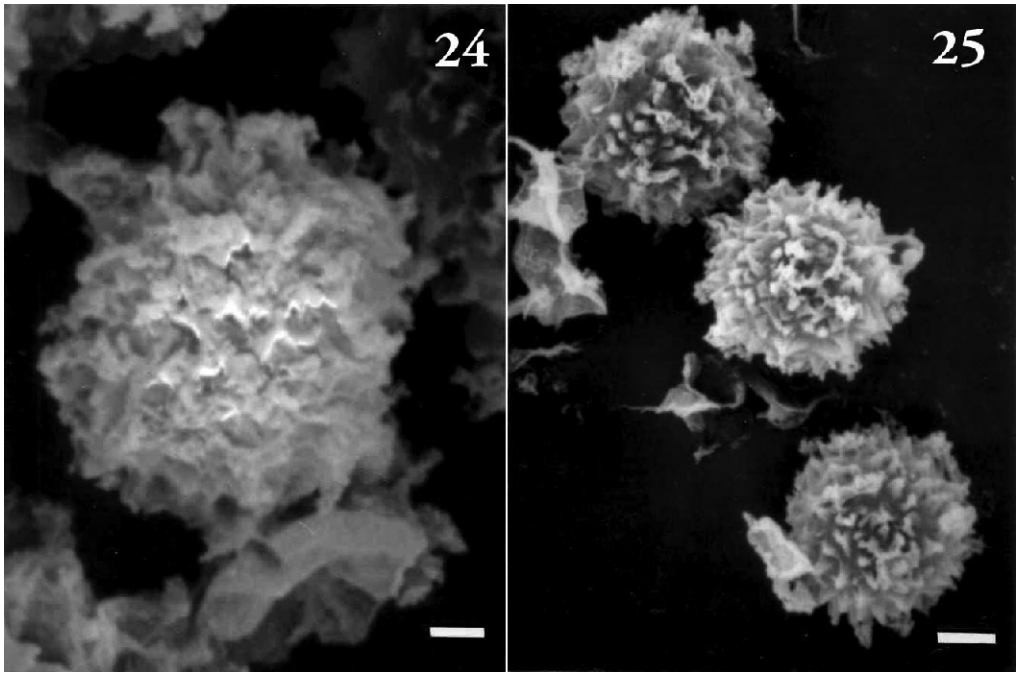


FIG. 24–25. Scanning microscopy of the spores of *Scleroderma stellatum* (24) and *S. bermudense* (25) (24 holotype, 25 Baroni 9814). Scale bar = 1 μm in FIG. 24, 2.5 μm in FIG. 25.

2004, *Baroni 9814,* comm. Lodge (CORT); 14 Jan 1998, *Miller 27237*; *27244; 27245; 27249; 27250* (all in VPI). Mona Island Commonwealth Reserve, Sardinera, 24 Sept. 1995, *Nieves-Rivera* PR-54 (IA; VPI); 24 Sep 1995, *Nieves-Rivera* PR-269 (MAPR; VPI); 25 Sep 1995, *Nieves-Rivera* PR-275 (UPRRP; VPI); 26 Sep 1995, *Nieves-Rivera* PR-193 (NY; VPI). BARBADOS, 24 Jun 1905, *Lewton* (*Lloyd 9123,* BPI); *Freeman* (*Lloyd 9128,* BPI). VIRGIN ISLANDS, Guana Island, White Bay Beach, 11 Oct 1998, *Clum G-58* (GUA 203); 19 Oct 1997, *Lodge G-74* (GUA 162); 3 Oct 1998, *Lodge & Clum G-22* (GUA 207). BRITISH VIRGIN ISLANDS, Guana Island, White Bay Beach, 19 Oct 1997, *Lodge* (GUA-162; CFMR; K); 3 Oct 1998, *Lodge & Clum* (GUA-207; CFMR); 11 Oct 1998, *Clum* (GUA-203; CFMR). CUBA, *Wright 895* (NY as *Stella americana*). DOMINICAN REPUBLIC, Prov. Higuey, Punta Cana Beach Resort, 16 Jul 2001, *Lodge DR-2100* (JBSD). U.S.A., FLORIDA, Mathemon Hammock, Sep 1942, *Singer F-801* (NY, F as *S. cepa* ?); Miami, *Singer F-680* (F as *S. cepa* ?). MEXICO, Quintana Roo, N of Puerto Morelos, 13 Nov 1981, *Guzmán 21096* (XAL); S of Tulum, 1 Nov 1984, *Chacón 2755* (XAL); near Cancun, 2 Nov 1984, *Guzmán 24785* (XAL); Yucatan, Dzilam to Telchac, near Chabian, 28 Oct 1984, *Guzmán 24742* (XAL); near Telchac, 5 Aug 1983, *Guzmán 23624* (XAL). GUERRERO, Ixtapa-Zihuatanejo, 16 Jun 1999, *Guzmán* 32973 (XAL).

Comments. Scleroderma bermudense is characterized by the structure and the stellate dehiscence of its peridium, subreticulate spores, absence of capillitium and the thin and ephimerous endoperidium, as in all the species of section *Sclerangium* Guzmán, where *S. bermudense* belongs, according to Guzmán (1967, 1970). The tramal hyphae were considered by Reid (1977) as capillitium, but following Guzmán (1970) the true capillitium is absent in Sclerodermataceae. These tramal hyphae are really the generative hyphae in the young trama of the gleba, which collapse and produce the typical ''nurse cells'' that surround the young spores. *Sclerangium bermudense* var. *trinitensis* by Reid (1977) is considered a synonym of the typical variety, because it was based only on the inflated mesoperidium elements, up to 26 μm wide.

Veligaster nitidum (Berk) Guzmán & Tapia. Doc Mycol 25 (98–100):188, 1995. FIG. 23

≡ *Scleroderma nitidum* Berk & M. A. Curtis., Kew J Bot 6:173, 1854.

= *Scleroderma tenerum* Berk. & M. A. Curtis, J Linn Soc (Bot) 19:346, 1869.

Veligaster nitidum, as discussed by Guzmán and Tapia (1995), is a pantropical fungus. Characteristics that separate the genus *Veligaster* from *Scleroderma* following Guzmán (1969) are mainly the subgelatinous patches of the upper part of the stipe and base of the globose peridium. This fungus was confused with *S. verrucosum* Pers. (Guzmán 1970), a temperate species, that differs in lacking subgelatinous patches on the peridium and having larger spores, (10–)11–13(–14) μm diam. The spores of *Veligaster nitidum* are (7–)9–11(12) μm. The known distribution of *V. nitidum* was from Costa Rica, Cuba, Mexico and Nepal (type locality) (Guzmán and Tapia 1995). *Sclero-*

derma tenerum reported by Dennis (1970) from Venezuela seems to belong to *Veligaster nitidum*. This fungus is reported for the first time from the Virgin Islands on Guana Island. The material was collected on soil, in a forest under *Pisonia subcordata* Sw.

Specimens examined. VIRGIN ISLANDS; Guana Island; Quail Dove Ghut, 16 Oct 1999, *Lodge G-167* (GUA 266, XAL); N Beach Road., 15 Oct 1999, *Lodge & Clum G-154* (GUA 252, XAL).

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